Steam Partnerships: Case Study of Improved Energy Efficiency

Michael V. Calogero
Robert E. Hess
Novi Leigh
Armstrong Service, Inc.

Effective energy management involves expertise in three core areas: commodity supply, generation (production), and distribution/utilization. Historically, energy providers have only been partially successful in fulfilling the needs of industrial energy consumers. They have supplied the energy commodities (fuel, electricity, or water) and may have even assisted with energy (steam) generation and production. But in most cases, their assistance and expertise came up short when dealing with the distribution and utilization of energy within the facility, particularly when addressing steam-based energy systems. (See Figure 1.) The fully integrated approach to energy management requires proven experience in the optimization of steam distribution and utilization, areas where the highest percentage of utility costs are variable.

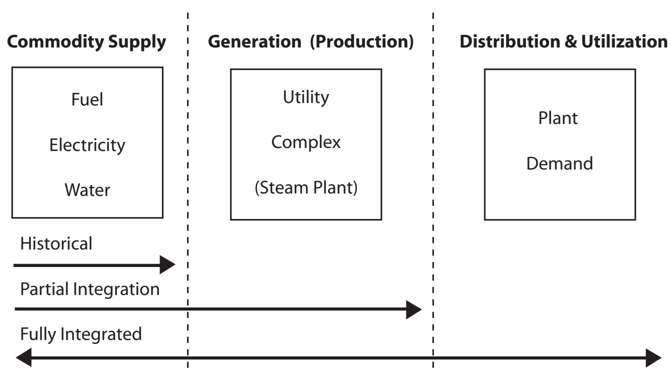

Figure 1. Degree of energy management integration.

A unique energy services alliance was recently structured and implemented with one of the largest health care linen service facilities in southern New York. The existing power plant was acquired from the client and upgraded. An extensive discovery-engineering audit was performed to identify major improvements that were subsequently made to the site utility systems. Particular emphasis was placed on the steam system, with most of the first phase optimization work directed at improving the distribution and utilization of steam energy.

Overall, this "steam partnership" captured a 17% average reduction in energy usage through the implementation of six energy savings projects. Outsourcing this activity allowed the client to refocus capital and internal resources on growing the core linen services business. To ensure continued interest by both parties over the 10-year agreement, a unique billing formula was structured that indexes total utility costs against laundry processed by the facility and provides incentives for both parties to drive down energy usage over the long term.

The responsibility for managing and tracking the supply of energy commodities was also transferred from the client. This integrated approach combines all three energy areas (supply, generation and distribution) under a single optimization entity. This paper describes the subject facility and the savings projects that were implemented. The results are summarized in a graph that shows an index of energy usage to laundry processed and compares a baseline period to actual performance after project implementation.

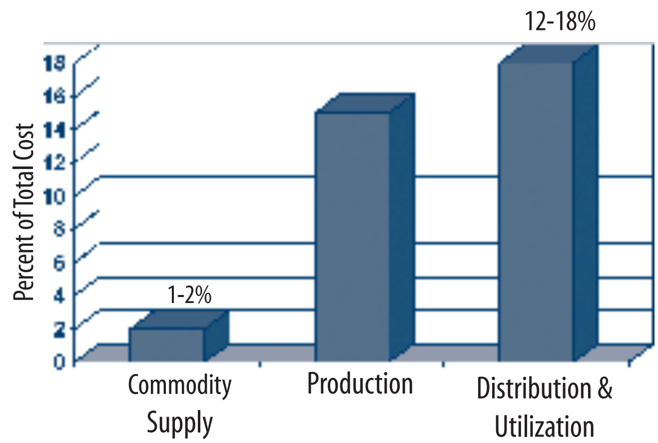

Figure 2. Controllable utility cost variances—steam generating complex.

In a light industrial steam generating complex, the highest percentage of variable controllable costs are found in the distribution and utilization areas. Typically, 12% to 18% of the as-found costs are variable and subject to optimization. This compares to 10% to 15% of the generation or steam production costs, and only about 1% to 2% of the commodity supply. (See Figure 2.) For this reason, most of the company's initial optimization efforts are focused on identifying and implementing savings opportunities in the plant distribution and utilization systems.

The first step in the optimization process was a site-wide, discovery-engineering visit to interview employees, observe operations, and record plant operating data.

Overview of the Laundry Processing and Steam Systems

The subject laundry facility processes about 120,000 pounds of institutional linen per week. The operations include multiple washing, drying, pressing, ironing, and dry cleaning processes.

The washing process takes place in Lavatec machines. In these tunnel washers, the linens go through a number of compartments. Each compartment requires a certain washing temperature. This is achieved by supplying softened water to the machine and heating it within the machine by direct injection of steam at 115 pounds per square-inch gauge (psig). Of the 11 compartments, four are supplied with direct steam injection to obtain the required temperatures of 140˚F to 165˚F. Several hot water tanks at the bottom of the machines store water at 95˚F. The hot water stored in these tanks is partly recycled water from the tunnel machine.

Next to the tunnel machines are the tunnel dryers. These dryers burn gas as the heating source. There are also tumble dryers that utilize steam to heat incoming air.

The ironing process, which takes place in ironers, uses a heated bedplate over which large metal cylinders revolve. These cylinders are covered in an absorbent material known as roller clothing. The linen passes between each steam-heated surface and roll. When the linen is passed from the last heated bedplate/roll, it should be dry, ironed and free of creases, and ready to fold. Garment presses are used to dry and iron individual garments. All of the processes and irons are fed steam even when temporarily idle, so effective condensate removal is very important.

Steam Generating System

The facility operates one of its two Cleaver Brooks boilers to meet its steam demand. The main boiler is the newer one (manufactured in 1986) with a rated capacity of 300 horsepower (HP), or about 10,600 pounds of steam per hour at maximum pressure of 150 psig.

The boiler operates about 12 hours a day, for 6 days per week. During the weekends in winter, the boiler needs to be turned on for about 4 hours to prevent freezing the pipelines. (We expect that increased heat retention after the insulation project will eliminate this need in the future.)

The boiler generates steam at 115 psig. There is no steam flow meter in the facility. However, from the boiler stack measurement and the gas bills, an approximate load of the boiler was obtained. Based on our measurements, the oxygen level in the stack gas was 5.8% and the stack temperature was 324˚F. Our evaluation showed that the boiler operates at an efficiency of 83.9%.

The boilers and dryers use natural gas. The boiler gas consumption is not separately metered; calculations indicate that 80% of the total gas is utilized in the boiler. Based on the gas consumption and the boiler efficiency, the average boiler load was 4,700 pounds per hour, or 44% of its rated capacity.

The facility performs intermittent boiler blowdown on a regular basis. Based on several water analysis results, the average boiler blowdown was only 2.2%. The analysis also showed that the boiler water conductivity was very high because of the low blowdown rate. The highest conductivity measured was 7,100 micromhos[1] versus a 4,000-micromho target.

There is no deaerating process as part of the boiler treatment. Instead, chemicals are injected into the condensate tank and the boiler. An inspection of the main boiler showed internal scale formation attributed to chemical treatment fluctuations and insufficient blowdown.

Steam Utilization

The laundry facility utilizes steam at 115 psig. The steam users are the Lavatec washing machines, drying, pressing and ironing machines, dry clean facilities, unit heaters, and radiators. As stated earlier, the Lavatec washing machines have a direct steam injection system.

Condensate Return System

Condensate is returned to a horizontal cylindrical condensate tank that is located in the basement where it mixes with softened make-up water. Two electric-driven pumps transfer the boiler feedwater to the boiler.

[1] A measure of conductivity. 1/ohm = 1 micromho

The condensate tank was venting flash steam to the atmosphere at a significant rate. Pressure gauges are installed in a few places along the condensate lines, most of which indicated 25 psig. Those in the laundry room and dry cleaning room showed between 7 to 12 psig. The high condensate pressure was caused by several failed steam traps passing live steam.

There is no meter to indicate the quantity of returned condensate. However, water analyses were used to estimate the percentage of returned condensate to the boiler house. Based on the conductivity analysis, the returned condensate was 55% of the total boiler feedwater.

Water Treatment

The facility uses city water in the softener to get better quality laundry and boiler feedwater. The softened water is also used in the Lavatec washing machines. A make-up water meter is available in the line that goes to the condensate tank.

Annual steam generating cost was estimated from the utility bills. Table 1 is a summary of the various steam-related costs. The steam generation cost does not include the cost of gas used in the dryers.

Presently, the facility pays for the same quantity of sewage water and raw water purchased. In the future, we will investigate reducing the sewerage cost by metering the sewer flow back to the city and requesting a credit for evaporation losses. Based on a plant study, evaporation at the dryers and irons is projected to reduce the measured sewerage flow by 35%.

Table 1. Various Steam-Related Costs (1999 Baseline)

Gas Cost	$4.12/MMBtu*
Heat Cost	$4.90/MMBtu
Water Cost	$0.90/M lbs**
Treated Water Cost	$1.44/M lbs
Steam Cost	$6.98/M lbs
Condensate Cost	$2.54/M lbs

* $/MMBtu = Dollars per million British thermal units
**$/M lbs = Dollars per thousand pounds

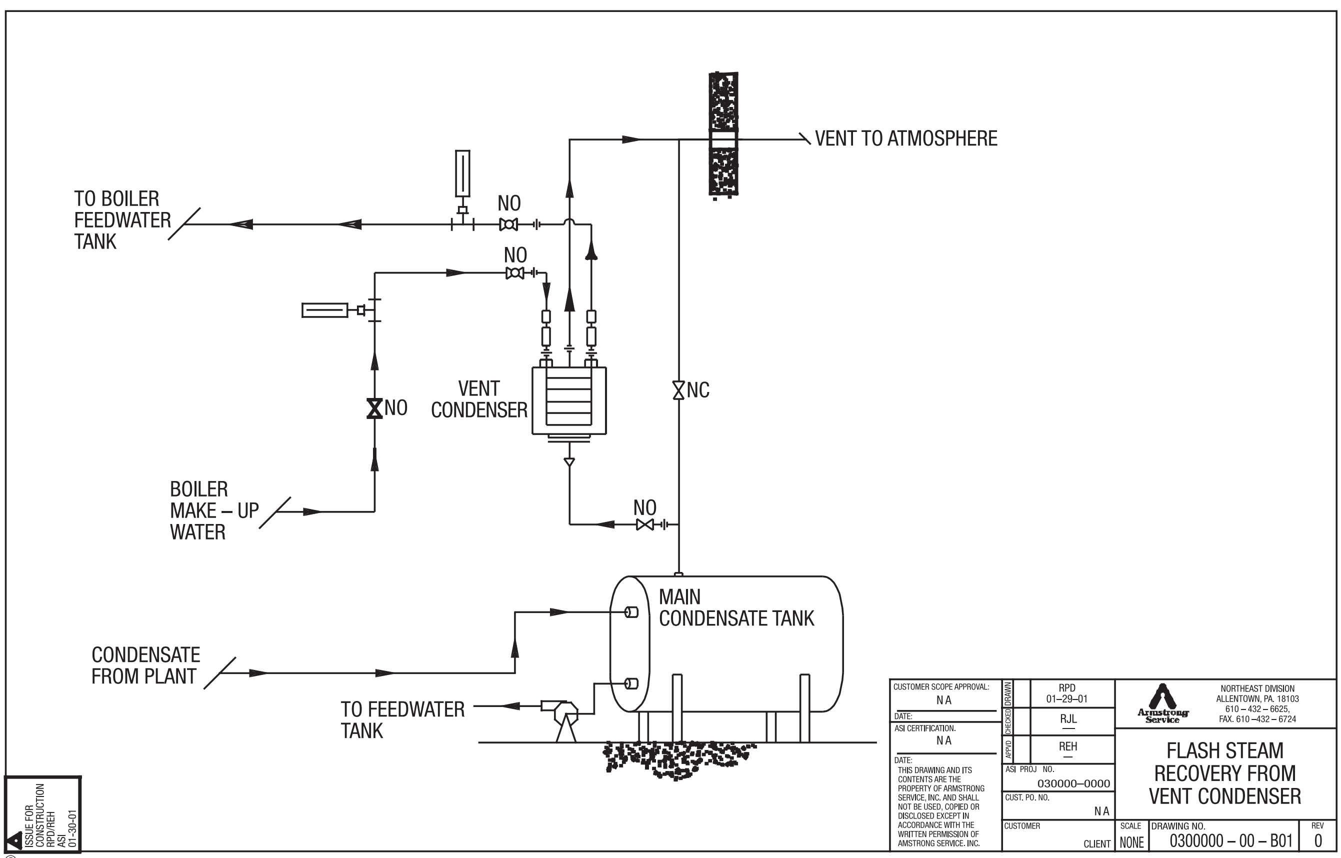

Figure 3. Vent condenser installation.

Saving Opportunities

A thorough review confirmed there are energy savings opportunities in the boiler system, steam distribution system and condensate return system. The following is a summary of the initial six projects that were implemented after the multi-year agreement was executed.

1. **Replace all identified defective steam traps.** There were 80 steam traps at the facility. During the comprehensive survey, 16% of the traps were blowing through. This resulted in an annual steam loss of 2.4 million pounds of steam.
2. **Repair live steam and condensate leaks.** The identified steam and condensate leaks accounted for 6.1% of the total steam generation. These leaks, including five isolation valves in the boiler room, were tagged and subsequently repaired.
3. **Improve steam quality to processing areas.** After analyzing complaints from plant employees about steam wetness, a major redesign of the main steam distribution system was made to improve the quality (dryness) of the steam exiting the boiler room. In addition, the steam supply and condensate return loops in the subject areas were also upgraded.
4. **Recover vented flash steam.** The condensate tank is vented to the atmosphere. A high quantity of vented steam is caused by the high-pressure condensate that is discharged at the lower pressure. This causes about 9% of the high-pressure condensate to be flashed. A system was designed to capture the flash steam energy by pre-heating boiler make-up water in a vent condenser. In addition to the heat savings, higher make-up water temperature improves the effectiveness of chemical treatment in the condensate tank. Figure 3 (previous page) illustrates the arrangement of the vent condenser installation.
5. **Insulate bare hot surfaces.** During the audit, we observed pipelines carrying either steam or hot condensate that were not insulated or poorly insulated. The condensate tank and some other hot surfaces, such as flanges and valve bodies, were not insulated. For safety reasons and to prevent excessive heat loss by radiation, hot surfaces must have effective insulation.

   The basic function of insulation is to retard the flow of unwanted heat transfer. Where justified, condensate lines were also insulated to capture the maximum heat that can be returned to the boiler plant for additional savings.
6. **Shut-off chemical treatment system when boiler is down.** There are two chemical pumps, each of which feeds chemicals to the condensate tank and the boiler. The boiler operates about 12 hours per day, 6 days per week. During the audit, we noticed that when the boiler was down, the chemical injection pumps were still on. After analysis and consultation with the chemical treatment supplier, we proposed to automatically shut off the chemical pumps when the boiler is down. This will save chemicals and water, and reduce heat losses because of less blowdown. Wide variations in boiler water conductivity would also be eliminated by this project.

Results

The identified savings projects were designed and implemented at the laundry facility. The impact of these projects is reflected in a plot of the gas utilization (decatherms of natural gas [DTH]) divided by thousands of pounds of processed laundry (PTS). In Figure 4, the lower curves represent the period after the projects were completed and are compared to a baseline period labeled 1999.

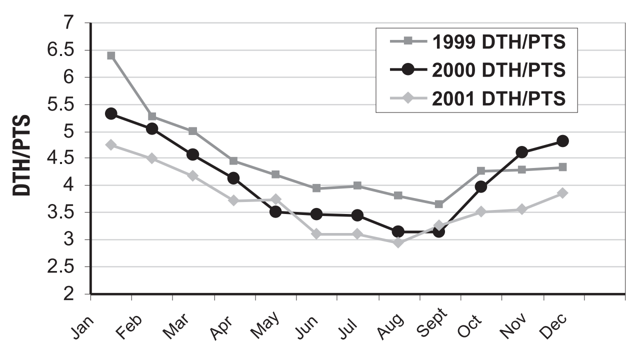

Figure 4. Gas utilization 1999 to 2001.

The overall result is an average reduction in the gas utilization of 17% over the baseline year.

For example, in the period labeled September, the gas utilization after optimization was 3.0 decatherms/thousand pounds (DTH/PTS) compared to a baseline index of 3.6 DTH/PTS. This represents a reduction of 16.7%.

Figure 4 also shows the impact of plant operations and equipment service factor on the gas utilization. During November and December 2000, an unplanned maintenance event occurred that forced the plant to operate with the less efficient back-up boiler. This boiler also suffered a control problem during the run. These upsets are reflected by the gas utilization exceeding the baseline for November and December 2000 despite the optimization projects. With normal operation restored by late December, the January 2001 utilization at 4.2 DTH/PTS was 20.8% below 2000 and 34.3% below the baseline year.

In Figure 5, the total utility costs per thousand pounds of processed laundry are plotted against a baseline index that was established prior to project implementation. This baseline index is depicted by the dashed line. The area below the baseline reflects the incremental savings generated by the projects on a total utility cost basis.

For example, in June, the actual monthly rate (AMR) was \$34.50/PTS compared to a baseline of \$44.15/PTS. The net utility cost savings were \$9.65/PTS, or \$4,600 at 475 PTS in the month and 1999 baseline utility prices.

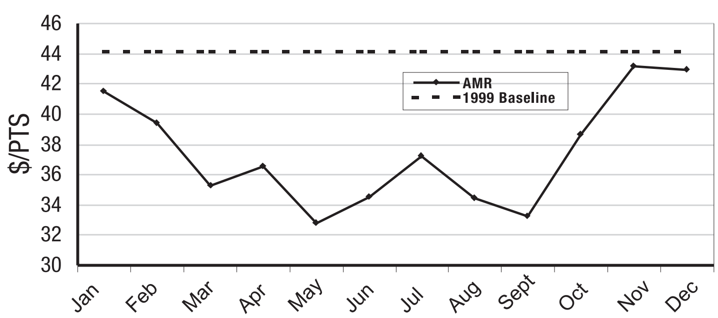

Figure 5. Actual monthly rate (AMR) in 2000.

Conclusion

The fully integrated approach to energy management produced an average reduction of 17% in gas utilization and an overall savings of 14% in total gas and electricity costs for the facility. Furthermore, the structure of the multi-year agreement is such that both partners will continue to seek out energy savings in the future.

Several Phase Two projects are already being scoped out. These include:

- Changing gas consumption tracking to reduce service fees
- Metering sewer flow to receive evaporation credit
- Using non-chemical water treatment to reduce chemical treatment costs
- Installing controls and insulation upgrade of older (back-up) boiler.

References

1. Americas Power Partners, Inc., *Financing Energy System Optimization*, Bulletin ASI/APP5M, 2000.
2. Operating data from client's laundry processing facility from 1998 to 2001.
3. Wayne, Turner C., *Energy Management Handbook*, 2nd edition, 1993.
4. Armstrong International, Inc., *Steam Conservation Guidelines for Condensate Drainage*, Handbook N-101, 1997.
5. Forenta Systems, *Technical Piping Tips*, Bulletin TT-69, 1993.